REVERSE ENGINEERING THE HUMAN BRAIN: THE KEY TO ARTIFICIAL INTELLIGENCE

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THE END GOAL

The concept of artificial intelligence is a wild fantasy that has been portrayed many ways in media throughout the years. Whether it is a robot assassin from the future or a small, blue droid from a galaxy far, far away, the technology seems very futuristic and out of reach. Over the years, humanity has made great strides in the field of robotics, such as contraptions that can play chess, play air hockey, or even shoot a basketball. Now, jumping forward to the present, engineers have finally begun to delve into artificial intelligence on a more human level. The first, and most important, step in this great endeavor is to reverse engineer the human brain.

THE SCIENCE BEHIND IT

While many professionals are doubtful that this process is even possible, Sebastian Seung, a scientist at MIT, argues that technology has reached a point at which he can begin mapping the connectome [1]. When interviewed, Seung describes the connectome as "a map of a neural network" [1]. The way that a person's neurons connect is what gives that individual a distinct personality. If these connections can be identified and mapped, the result will not only allow for advances in the field of neuroscience, but also make visions, such as true artificial intelligence, possible. Obviously though, this is no simple task. When prompted, Seung stated, "Indeed, mapping an entire human connectome is one of the greatest technological challenges of all time. Just imaging all of a human brain with electron microscopes would be difficult enough. This would yield about one zettabyte of data, which roughly equals the world's current volume of digital content. Then analyzing the images to extract the connectome would be even more demanding." [1]. As daunting of a task as this seems, he is still very confident that is can be done, and is willing to dedicate the necessary time to the endeavor. In my opinion, the logic behind his statements is justified, and I do believe that it is time for humanity to take this great leap into the future.

Another regarded scientist, David Alder, a neurobiologist at Howard Hughes Medical Institute, believes that the fusion of human intellect into machines is entirely possible. He has been recently attempting, along with a team of engineers, to image and map the brain of a fruit fly [2]. Although much simpler, Alder argues that the science is transferable to the human brain. The technique involves slicing off sections and imaging the neural pathways with a scanning electron microscope [2]. "His vision is a Google map of the human brain" [2]. This thought seems to parallel Seung's idea for a connectome, being equally ambitious and beneficial. Alder uses a ten-billion-pixel-per-second microscope, which he says will allow him to image with the same sharp resolution that is seen in Google's satellite imaging. The brain data that this instrument can yield will allow for not just the mapping of neural pathways, but of the human consciousness. (memories, emotions, and behavior). Alder states, "If you can understand how memories are formed, you can create memories" [2]. I found this fascinating, since this technology would allow for artificially intelligent machines to exhibit human characteristics, proving the previously stated science fiction fantasies to be entirely possible.

After learning about Alder's work with fruit flies, I was curious if similar, successful work was being done one on larger organisms. After a little digging around, I came across Alan Jones, a scientist who was employed by Rosetta, a genomic testing company [3]. Jones had succeeded in imaging the entire brain of a mouse, collecting the images into one publication titled The Mouse Brain Atlas [3]. This was remarkable to me that such a complex process could be applied to a microorganism with a much larger brain than that of a fruit fly. This, in my mind, confirmed Alders belief that the same technique could be applied to a human's brain. Throughout the creation of The Mouse Brain Atlas, Jones was under the employment of a man named Paul Allen. Allen was a philanthropist with a passion for the advancement of neuroscience, and he went on to create The Allen Brain Atlas [4]. This is a rough heatmap of neural activity across the brain [4]. This gave scientists a fuller understanding of brain activity than ever before, showing trends and patterns. For example, the brain's cerebral cortex consists of almost perfectly homogenous neural pathways [4]. Also, the hippocampus, which is responsible for learning and memory, exhibits a very distinct pattern of gene expression [4]. This completely new information is groundbreaking for scientists like Alder, who are interested in the way that neurons interact

to preserve and create memories. Allen's atlas does in fact reveal the extreme complexity of the organ though, making the task ahead of the previously mentioned scientists appear even more impossible that it originally did.

The road to a full understanding of the human brain is a long and arduous one, and this technology is extremely necessary to create artificial intelligence with the characteristics of a human, but that does not mean that there are not already impressive, groundbreaking robots out there that exhibit human characteristics. For example, Maggie is a machine in MIT's Department of Brain and Cognitive Sciences that solves complex logic questions [5]. These questions are deigned to require that she generate abstract representations and then use those abstractions as tools, and she completes them at a rate of less than one second per question [5]. This is revolutionary for a computer, and involves the use and application of very human traits, such as logical reasoning and recognition. Maggie was a product of artificial intelligence and neuroscience, two fields that are becoming increasingly more intertwined every day, according to James DiCarlo, assistant professor of neuroscience at MIT [5]. DiCarlo's lab focuses on object recognition among robots. This involves programming machines to "understand" that a cow is a cow, no matter what angle it is viewed from. The sensor must also be able to tell the difference between a cow and a similar object, such as a horse. DiCarlo recently conducted an experiment to determine how much of our success in recognizing objects depends on hard-wired circuitry, and how much on learned skills, an essential question when it comes to artificial intelligence [5]. The results suggested that a large portion of recognition is through hard-wired pathways, not experience, a very positive sign for the world of robotics.

Lastly, I was incredibly excited to see that a neighboring school, Carnegie Mellon University, has joined the cause to reverse-engineer brain algorithms [6]. In particular, the researchers seek to improve the performance of neural networks, which are computational models for artificial intelligence inspired by the central nervous systems of animals [6]. This endeavor will end up costing around twelve million dollars and spanning over the course of five years [6]. Tai Sing Lee, leader of the project and professor for Computer Science Department and the Center for the Neural Basis of Cognition, stated that the project "is similar in design and scope to the Human Genome Project, which first sequenced and mapped all human genes" [6]. By this he means that it will cause an everlasting impact on the fields of science and engineering, and revolutionize the world around us. I could not agree more, and I am fascinated to see that this issue is so prominent in current day science that it is being studied at facilities within walking distance of my residence hall, along with others around the world.

A BRIGHTER FUTURE

All in all, I strongly believe that today's technology is ready to make this great leap forward. The brain is the last frontier of the human body, and many great minds around the world believe that it can be explored completely. From what I have learned, I would be shocked if a complete map of all neural pathways and features is not available in the next thirty years. Also, the field of artificial intelligence will not be far behind. With access to this revolutionary wealth of knowledge, AI engineers will be able to emulate the functions of the human brain in robots. The real-world applications of these technologies, should they be developed, are invaluable. Machines with "brains" will be able to replace human labor in jobs that are dangerous, and will also create an unlimited labor force. Just imagine the possibilities. We may not live in a world where human-like robots are commonplace, but trust me (and the professionals), we will soon enough.

SOURCES

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